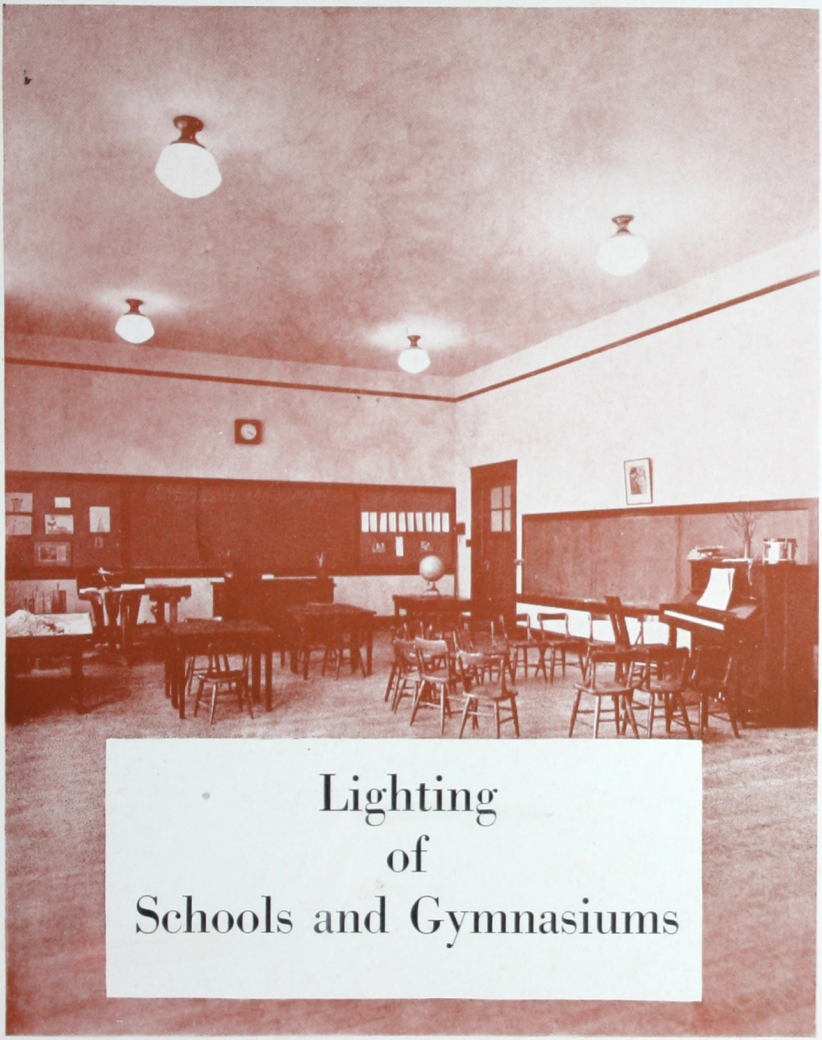

Lighting of Schools and Gymnasiums

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At the Edison Lighting Institute, dedicated to the public for the advancement of the art and science of illumination in its many and varied applications, are portrayed most dramatically hundreds of uses of light.

Lighting of Schools and Gymnasiums

Information compiled by
A. L. Powell and D. J. Frandsen
Engineering Department

Night view of a grammar school classroom specially lighted for the benefit of children with defective vision. Six 300-watt lamps are used in color modifying glass enclosing globes mounted on the ceiling. The room is 24 ft. by 32 ft. with a 12 ft. ceiling. Six 25-watt MAZDA lamps are used for the lighting of the side blackboards. The average illumination on the desks is 15 foot-candles, and blackboards are lighted to the same level.

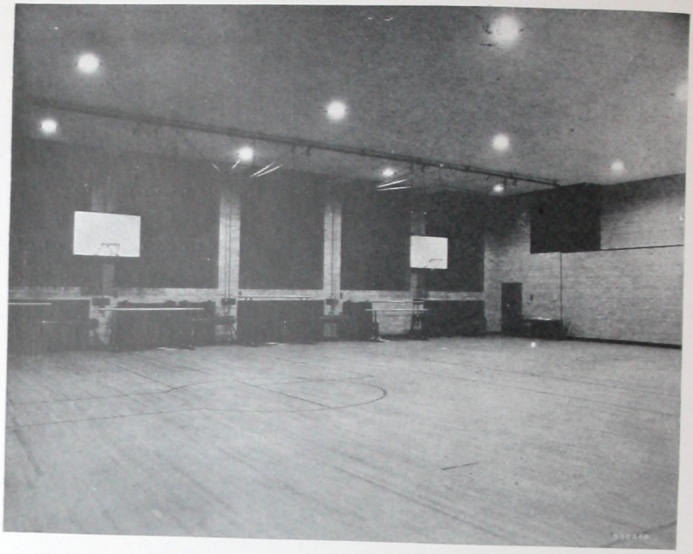
SYNOPSIS: PAGE

SCHOOLS

GYMNASIUMS

For information regarding MAZDA lamps and lighting questions, refer to the nearest sales office, as listed on the last page of this bulletin.

To insure receipt of bulletins, notify the Department of Publicity, Edison Lamp Works of the General Electric Company, Harrison, N. J., of any change of address.



Night photograph of high school gymnasium. Deep mirrored glass reflectors recessed in the ceiling are used in this installation. 300-watt clear MAZDA lamps provide an average illumination of 6 foot-candles over the floor area. The high mounting, 20 ft., eliminates to a great extent any likelihood of glare. The ceiling is relatively dark, due to the fact that there is no direct light falling upon it.

An attractively finished swimming pool lighted by 200-watt MAZDA lamps in opalescent enclosing units on 12-ft. centers above the pool proper. Small direct lighting units are used beneath the balcony.

Lighting of Schools and Gymnasiums

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Necessity for Adequate Illumination

Artificial lighting should be provided for all schools. Even though most of the school work is done during daylight hours, there are inevitable cloudy or stormy days which necessitate supplementary lighting. It is little realized how much of the day is spent in semi-darkness. In December, for example, there is an average of only five hours of sunlight per day. In the vicinity of New York, cloudy days comprise approximately 40 per cent of the school year. Obviously, artificial lighting of the proper kind must be provided, in order that the children's eyes may be protected and school work carried on in a satisfactory manner. Artificial lighting must receive special consideration, for a satisfactory combination of natural and artificial light is one of the most exacting problems. Moreover, during the last few years, the schools have become over-crowded, making night sessions a common practice, with good lighting a necessary requisite.

Data on school children, year after year, show increasing amounts of eye defects. For instance, 10 per cent of the children entering school are nearsighted, while about 33 per cent are nearsighted at the end of the eighth year. To quote Dr. William M. Howe of the New York State Department of Education:

> "I believe that in time any school service that does not prevent most of these ocular defects, with which we are meeting so often, will be considered inefficient and derelict in its duty to school children. There is something intrinsically wrong with any educational system that permits from 8 to 15 per cent of its children to acquire defective vision within the few years of their school lives. Few children as you know are born with defective eyes."

That defective vision is acquired and is often progressive, is shown by the fact that eye troubles are more prevalent among children in the advanced grades. In most cases the child receives his first exacting eye work when he goes to school, where, of necessity, a large quantity of printed and written matter is placed before him. It can be easily understood how a child born with normal vision, but forced to do detailed work oftentimes under inadequate illumination, develops poor vision. Indeed, it is difficult to appreciate the value of education, if, in acquiring it, one must also acquire poor eyesight to limit its application. It is essential that good

illumination be provided in the schools so that those pupils whose eyes are normal may see properly, and that those with defective vision may do better work.

That adequate illumination can offset to a great extent the handicap of defective vision was effectively demonstrated in tests conducted on a group of children who were decidedly backward in their studies. These children were observed under various levels of artificial illumination, and a marked increase in mental alertness

Night photograph of classroom specially lighted for pupils with defective vision. The room is 24 ft. by 30 ft. with a 13 ft. ceiling. Eight 300-watt MAZDA daylight lamps in enclosing globes provide a uniform illumination of 14 foot-candles. A closer approximation to daylight is obtained than is possible with clear lamps.

was noted as the light under which they worked was increased The progress of these children under the higher levels of lllumination was so gratifying that specially lighted classrooms have been installed for their benefit. In this connection alone, proper lighting of the school room is an economy, as the cost of teaching a pupil who is forced to spend an extra year in school because of defective vision more than offsets any saving in lighting expenses.

The American City Bureau reported a few years ago that the average cost of teaching each child per year was $57.00. The

average child will reach the eighth grade at the age of 14 years at a cost of $456.00 to the state. If, on account of defective vision caused by poor illumination, or slowness due to lack of visual stimulus, the child reaches the sixth grade only, the cost to the state has been the same, with only three-fourths the result. The state loses money, and the child will probably leave school poorly prepared to earn a living. At a cost of only $1.50 per child per year good illumination, which would tend to decrease greatly eye troubles and resultant backwardness, can be provided.

In the majority of schools arrangements for daylight are generally satisfactory, but the artificial lighting is frequently inadequate. Systems in use often consist of bare, clear incandescent lamps, and, where reflectors are used, they are frequently hung in such positions as to cause eyestrain. In many cases suitable luminaires, properly located, are provided, but the level of illumination is far too low, due to the fact that lamps of too low wattage have been used.

Before entering into a description of the method of securing proper results in school lighting, it is well to sum up a few of the desirable qualities of illumination, and then to show by illustrations, accompanied by data, examples of these principles applied to typical buildings.

School Lighting Codes

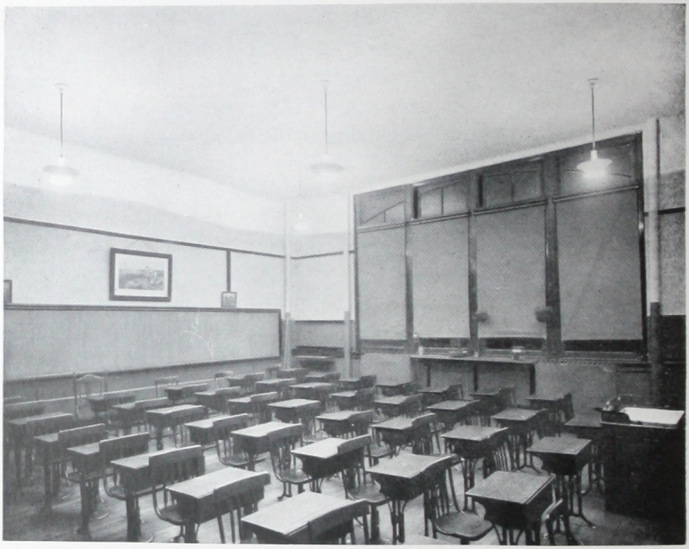
Proper school illumination is so important in ensuring future public health and visual power that various welfare and educational associations have taken an intense interest in improving the practice and preventing the exposure of school children to eyestrain, which has been altogether too common in the past.

In 1918, the Illuminating Engineering Society, which had already proposed an industrial lighting code, issued a Code of Lighting School Buildings, setting up minimum standards of schoolroom illumination. The State of Wisconsin and the Department of Education of the State of New York adopted regulations based thereon.

The I.E.S. School Lighting Code was later revised to incorporate later experience and adopted in June 1924 as an American Engineering Standard, under the joint sponsorship of the American Institute of Architects and the Illuminating Engineering Society.

The essential features are the standards for adequacy of illumination and for the elimination of glare. The rules are accompanied by helpful suggestions and detailed explanations of factors affecting

illumination. As a result of wide distribution of the code by the Illuminating Engineering Society, welfare organizations, and certain governmental bureaus, there has been a growing appreciation of the importance of proper illumination on the part of school boards, and a marked improvement of practice. Nevertheless, there are still many schools where pupils are exposed to deleterious conditions which are undoubtedly injurious to vision and likely to decrease the future earning capacity of the unfortunate victims.



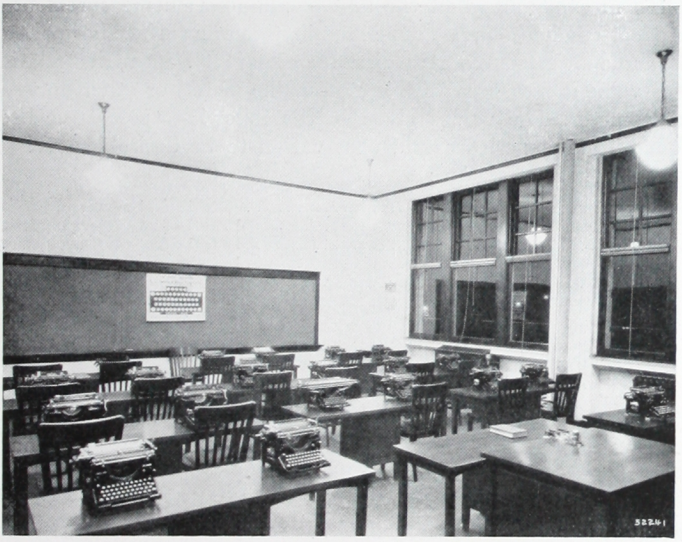
These attractive metal and glass semi-indirect units provide excellent, well-diffused light without direct or reflected glare. The absence of annoying reflections from the polished desk tops should be noted.

School work involves change to a new task as soon as an old one is mastered. Office and factory workers, on the other hand, usually continue working on processes after habit has lessened the demand for close vision. In view of these conditions, and the immaturity of students' eyes, the various forms of school work should have better illumination than the corresponding industrial processes. The reverse is in general more common. Due to economic considerations of private business, the value of increased production has, to the advantage of the wage earner, become more widely

recognized. Greater attention is still needed to ensure the welfare of school children.

The National Committee for the Prevention of Blindness and The Eyesight Conservation Council have been especially active in promoting the practices specified in the code and have issued literature to supplement it.

The code, which provides an excellent guide to good practices of school lighting, covering both natural and artificial light, is com-



For this room used by classes in typewriting, four prismatic glass units, using 300-watt MAZDA lamps and so designed that the greater part of the light is directed toward the ceiling, supply adequate diffused illumination. An intensity of 12 foot-candles over the floor area of 26 x 30 feet facilitates rapid and accurate work.

mended to the attention of those having to do with school illumination. It is published by the Illuminating Engineering Society in the form of a pamphlet of about forty pages. The rules themselves occupy only three pages, the remainder being devoted to illustrated treatises on school lighting practice.

It is understood that copies can be secured from the Illuminating Engineering Society, 29 West 39th St., New York City.

Qualities of Good School Lighting

Level of Illumination

It is self evident that a suitable amount of light must be supplied, if work of any kind is to be properly performed. Correct illumination is necessary in order that everything which is to be seen may be seen clearly, and without causing eyestrain. Regardless of what type of lighting system is used, a sufficient amount of light must reach the work, otherwise the system must be considered as being inadequate and improper. It is not necessary to go into technical detail in explaining that the unit of illumination measurement is the foot-candle (defined as the illumination of a surface normal to a 1 candlepower source at a distance of 1 foot). In an installation this value is measured with a foot-candle meter, or other portable photometer. The values given in the following table have been found from experience and observation to be desirable levels of schoolroom illumination:

Classrooms	8 to 12 foot-candles on desk
Study room	10 to 12 foot-candles on desk
Office	10 to 12 foot-candles on desk
Drawing room	15 to 25 foot-candles on tables
Laboratories	8 to 12 foot-candles on tables
Cloak room	1 to 3 foot-candles on floor
Corridor	2 to 5 foot-candles on floor
Auditorium	3 to 6 foot-candles on floor
Auditorium (if used for study room purposes)	8 to 12 foot-candles on chairs.

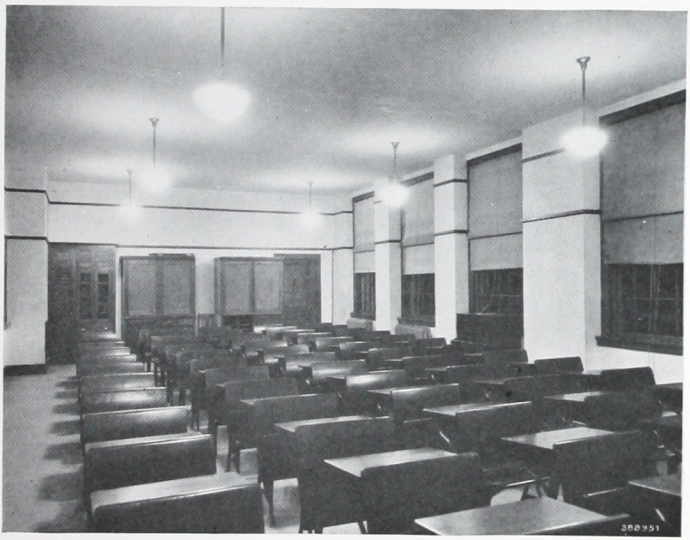
Even though adequate light can be supplied for any process, it is inadvisable to permit the young child to do fine needlework under artificial illumination. The periods should be so planned that this work may be done by daylight.

While such values as given above will produce satisfactory results, the higher, rather than the lower, levels are recommended. With the higher values of illumination an increased degree of perception is obtained, and better results may be expected. If increased production in industrial plants and offices can be profitably brought about by high level lighting, why should not increased speed and accuracy of accomplishment on the part of the pupils likewise be worth while?

As an unfortunate result of our economic system, students are usually compelled to work under less light than is provided in industry for similar operations. In reality, more light is needed. because the pupil in the process of learning has to give closer visual attention than a workman, to whom a process becomes more or less automatic.

Diffusion

The harmful effects of glare cannot be overemphasized. Anyone who has happened to glance, even for an instant, into the extreme brightness of the noonday sun will realize the extreme strain and eye fatigue incident to such a procedure. With the development of more efficient lamps with their increased intrinsic brilliancy, the likelihood of harmful glare from artificial light sources is becoming greater. Practically all commercial light sources



Night view of classroom and study hall lighted by eight 200-watt MAZDA lamps in squat type, opal enclosing globes. The room is 21 ft. by 49 ft. and has a 13 ft. ceiling. The luminaires are mounted on 12 ft. spacings at a height of 9 ft. Average illumination 9 foot-candles.

are far too brilliant to be in the field of view without producing a blinding effect and reducing the ability to see. When bright light sources are placed high above the head, the eyebrows protect the eyes, as will be noted out of doors under the sun. But, from the construction of our buildings, illuminants must be hung rather low and come within the field of view. We must, therefore, always reduce the brilliancy of the light by means of diffusing globes, shades, or reflectors, which either effectively enlarge the light sources or

actually hide them from view. Diffusion also softens the shadows, so that severe contrasts are less likely to occur. It is not desirable, however, to go to such an extreme diffusion that we entirely eliminate shadows, for they are very essential to show the contour or shape of objects. Over-diffusion, or flat illumination, is trying to the eyes and is quite unpleasant.

Not only must light sources with proper diffusing qualities be installed, but the walls and other objects also must be given attention. Dull, rather than polished, surfaces are desirable, and even a depolished or wax finish is more desirable than varnished or highly polished surfaces on the desks and other furniture, as the latter produce mirror-like effects, in reflecting the light sources. In this connection, attention should also be given to the desirability of matt rather than glossy finished paper, for paper with a glossy finish likewise reflects light in an annoying manner.

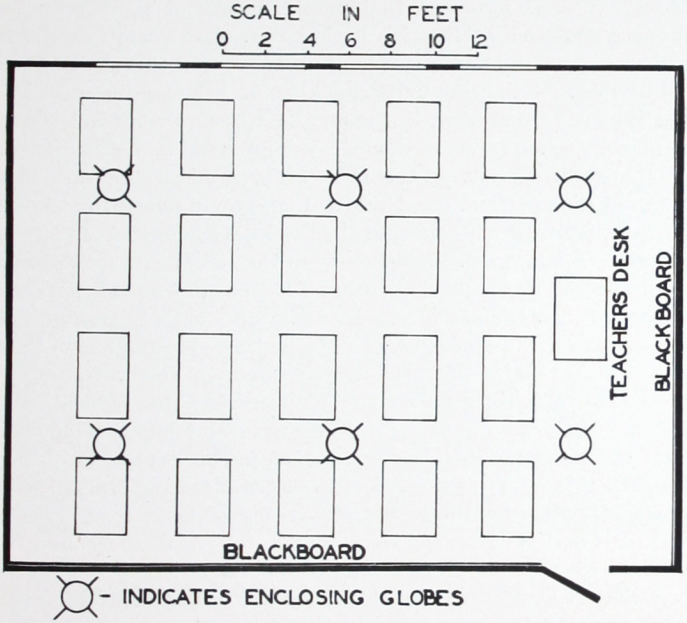
When we think of diffusion, its antithesis, glare, also comes to mind, and, as pointed out, intrinsic brightness is one of the greatest sources of glare, although it is not the only cause. A large area of low intensity may be very annoying. Everyone has experienced the glare from a cloudy sky. Excessive contrasts may produce glare. This can be illustrated as follows: a bright incandescent lamp in a dark room is most annoying, whereas the same lamp if viewed in an open window against the sky is not at all noticeable. This has a practical bearing in the schoolroom where blackboards are adjacent to white walls of high brightness.

Distribution

Distribution of light has two extremes: local lighting and general illumination. In local lighting relatively low wattage lamps, located close to the work, furnish a high level of illumination over a small area. Such a system usually abounds in those conditions which cause eyestrain and eye fatigue. The lamp is often under the control of the pupil, who knows little of its use, and often works in his own shadow. Drop cords or reflectors are often tied back, which is, in itself, a dangerous practice, so that those pupils working at adjacent tables are subject to annoying glare. In general, the use of local light in a schoolroom cannot be too strongly condemned.

In general illumination much larger lamps are used, hung as high as possible, providing almost uniform lighting throughout the room; in fact, there is a much more uniform intensity across a room than is possible with natural lighting from windows as

ordinarily placed. It simulates daylight, makes the room appear much brighter than local lighting, is, in general, independent of the arrangement of furniture, and, without question, is the system best suited for schoolroom lighting. The wiring cost is much lower, there is less likelihood of glare, and little danger of breaking lamps or reflectors.



Typical classroom (24 ft. by 32 ft. by 13 ft. high) illustrates a desirable arrangement of outlets for direct lighting luminaires. Using enclosing diffusing globes the following approximate values of illumination would be obtained: with 200-watt MAZDA lamps, 8 foot-candles; with 300-watt MAZDA lamps, 12 foot-candles. With a semi-indirect system four outlets would be sufficient. The approximate values with 300 and 500 watt MAZDA lamps would be 7 and 14 foot-candles respectively.

The Lighting of Classrooms

It is natural and essential that the light should be directed on the objects to be seen and not directly to the eye; therefore, since it is necessary to hang lamps high and out of the line of sight, we must equip them with reflectors or other devices to direct the light to the desks, or to the ceiling to be reflected downward. It is always desirable to shield or diffuse the light at angles near the

horizontal and to provide as even an illumination throughout the room as is possible. Although a certain variation is permissible, the ratio of the maximum to the minimum level of artificial illumination, measured in foot-candles at the desk tops, should always be less than four. A symmetrical spacing of outlets is therefore essential.

More outlets are required for the direct lighting than for the indirect system, in order that multi-directional light may be provided, and the distribution be uniform. It is always desirable to hang units as high as possible in order to keep them out of the field of view. No lighting units should come below a line extended from the eye of a student in the rear seat to a point 2 feet above the blackboard. In no case should the lamp itself be easily visible.

Light-colored walls and ceilings are very desirable with any system of illumination. Matt rather than glossy finishes are to be preferred, for with matt finishes the possibility of reflected glare is reduced to a minimum. Light falling on the ceiling gives a cheerful appearance to the room, and, when reflected downward, it tends to reduce contrast and soften shadows. Dark-colored surroundings greatly reduce the efficiency of any lighting system, since they absorb, rather than reflect, the light falling upon them.

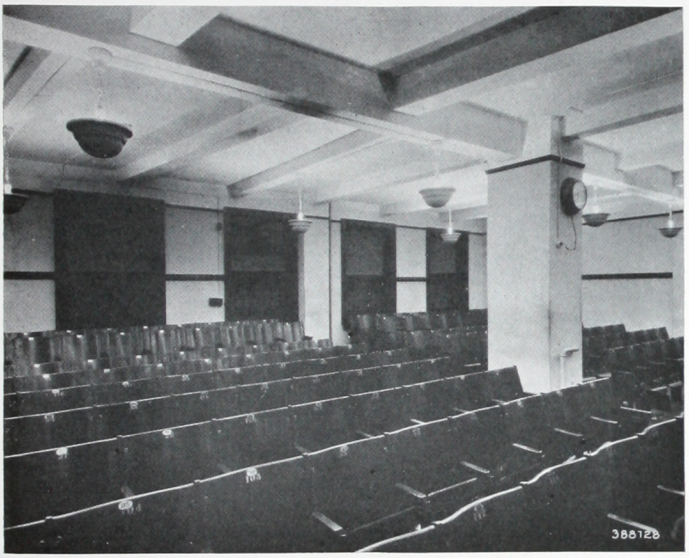
The fixture in the ordinary classroom serves a purely utilitarian purpose—that of supporting the glassware and lamp. It should, therefore, be simple in character; the means of suspension of any type of lighting unit should be such that there is absolutely no danger of glassware falling, and, especially in the case of indirect units, it is desirable to have some convenient means of cleaning.

The wiring should be so arranged that the switches are readily accessible. It is often advisable to have one circuit controlling the lamps near the teacher's desk, so that he or she may work after hours without having the whole room lighted; the remaining lights should be on a separate circuit.

Convenience outlets (baseboard or wall-types) are a most desirable feature of the wiring layout for the schoolroom. These enable vacuum cleaners, electric floor mops, and scrubbing devices to be used at will. They provide a means of attaching electric fans and other appliances of this nature.

There is a likelihood of glaring reflections from blackboards, and they should, therefore, always have matt, rather than polished, surfaces. It is sometimes possible to eliminate reflection by tilting the board slightly. Blackboards which will be written on with colored chalk and those that are more than 20 feet away from the

pupil should be specially lighted to a level approximately 60 per cent higher than the rest of the room. This can be accomplished by the use of properly screened and judiciously placed local units, similar to the systems commonly used on outdoor signs, etc. Blackboards should never be located between windows, since the



A large lecture hall as it appears by night, lighted by 200-watt MAZDA lamps in mirrored glass totally indirect fixtures. A uniform illumination is thus provided.

contrast between the black surface of the board and the bright sky will be too great for eye comfort.

Direct, semi-indirect, and totally indirect systems are all employed for school lighting. There are a number of factors which must be taken into consideration in the selection of lighting equipment. These are briefly stated below:

Quality of illumination produced
Convenience of maintenance
Appearance of the installation
Efficiency of the system
Ability to produce the desired illumination
Cost of installation

Obviously, the type of lighting equipment to select is that which will give a desirable quality of illumination in as efficient

manner as possible over a long period of time. The general appearance of the unit is important, but this is largely a matter of personal opinion and is impossible to evaluate. Any decoration of luminaires should be very simple, for appearance of excessive ornateness is out of keeping with the character of the schoolroom. Deep crevices in glassware, although they might be considered attractive, are objectionable from the standpoint of dust accumulation.

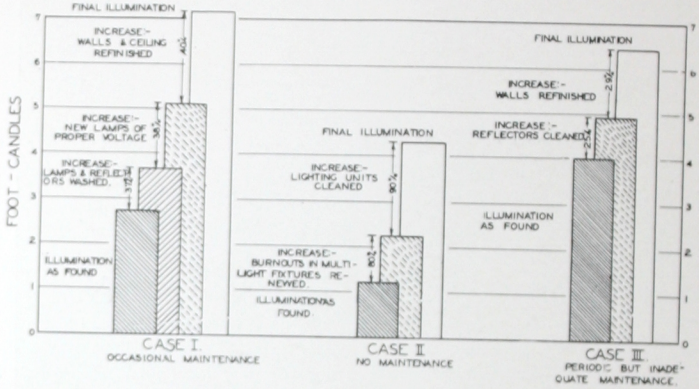


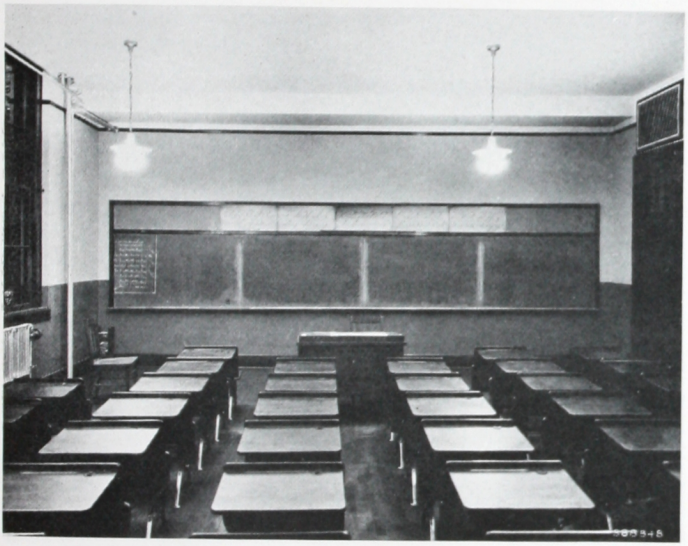
Chart from Illuminating Engineering Society *Code of Lighting School Buildings* showing the importance of prompt renewal of burned-out lamps and systematic cleaning of lighting equipment. Tests on semi-indirect and indirect lighting systems.

The proper maintenance of a lighting system in any class of service is of such importance that it has been deemed advisable to treat this subject in considerable detail in a separate bulletin, LD-101B, *Effect of Maintenance and Color of Surroundings on Resultant Illumination.* Great emphasis must be laid on this detail in the schools, for supervision is usually meager, and the periods between cleanings are of considerable length. These conditions should not exist; but nevertheless they do exist, and must be kept in mind when planning the lighting.

Totally indirect systems produce a very good quality of illumination, but require a relatively high wattage for a given level. With such a system there is little possibility of glare, and the light is soft and comfortable; glaring reflections are at a minimum, contrasts are reduced, and shadows are softened. The inverted bowls, however, tend to accumulate considerable dirt, and unless they are frequently cleaned the light output is materially reduced. A well

supervised system of maintenance is absolutely essential where totally indirect lighting is installed.

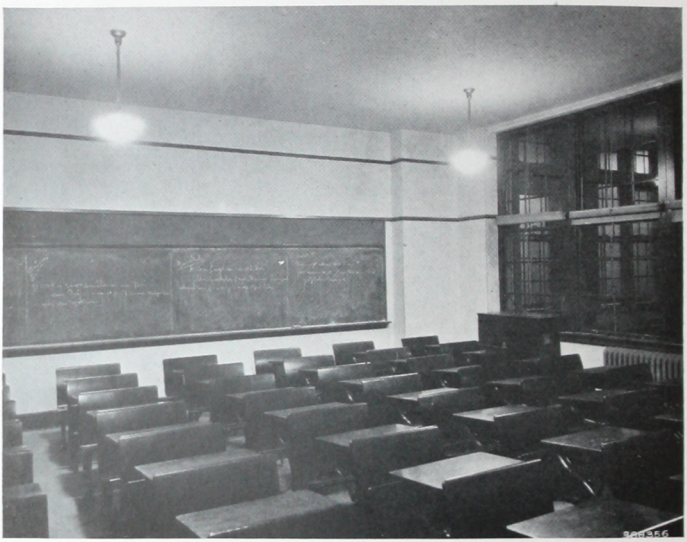
Semi-indirect lighting is an intermediate step between the direct and totally indirect systems. Luminaires employed in this type of lighting direct most of the light toward the ceiling, while a relatively small portion is transmitted downward through the glassware. Such a system is slightly more efficient than totally indirect lighting; the resultant illumination is well diffused, and such shadows



Night view of a classroom lighted by metal and glass semi-indirect units. Diffusion is excellent, direct and reflected glare are at a minimum, and a neat appearance is presented by the installation. Four 300-watt, all frosted, MAZDA lamps are used, providing a uniform illumination of 9 foot-candles on the desk top.

as are produced are soft and cause no annoyance. The best forms of semi-indirect units employ dense glass or some other means of reducing the brightness of the lighting unit. This type of lighting is particularly well adapted to schoolrooms, especially so if the totally enclosing type of semi-indirect luminaire, of which the upper portion is of clear glass, is used. An open type, semi-indirect unit is subject to the same objections as are applied to the totally indirect luminaires, in regard to accumulation of foreign materials, and consequent reduction of light output.

In many of the older installations, open bottom direct lighting units are used. Such a system is obviously efficient from the standpoint of light utilization, but the diffusion is not of the highest quality, shadows and contrasts are likely to be rather severe, and direct and reflected glare become serious, particularly if clear bulb lamps are employed. The use of this form of lighting is advisable only where costs must be kept at a minimum, and where secondary consideration is given to the quality of illumination. For such



Night photograph of classroom, 21 ft. by 21 ft., with a 13 ft. ceiling. Four 200-watt lamps in enclosing globes give a uniform illumination of 10 foot-candles on the desk tops.

lighting, it is deemed advisable to use dense opal or etched prismatic deep bowl reflectors. These transmit but a small portion of the light, and are, therefore, not very bright. Flat type reflectors should never be used in a schoolroom, for it is almost impossible to conceal the filament from view when using this style of shade. Opaque reflectors are, of course, generally unsuited, as the ceiling will be very dark when they are used. Diffusing bulb or white bowl MAZDA C lamps should always be employed in preference to clear lamps, as these finishes produce better diffusion, reduce reflected glare, and soften shadows.

The enclosing, diffusing, direct lighting luminaire seems to be, at the present stage of the art, the equipment most generally applicable for classroom lighting. If the proper type is chosen, a well diffused illumination, free from direct or reflected glare, is produced. Although the major portion of the light is directed downward, a considerable amount is transmitted upward, thus giving a cheerful appearance to the room and a character of illumination quite similar to that produced by semi-indirect units. Such equipment is easily cleaned, and, in general, does not depreciate as rapidly from the accumulation of dirt as do other fixtures providing the same quality of illumination. This should not be taken to mean that cleaning can be neglected, for it is always of primary importance.

The question has often been raised of whether it is necessary to provide ventilation for a totally enclosing unit. Carefully conducted tests have indicated that, with sufficient radiating surface—in other words, an adequate size of globe and fixture—ventilation is unnecessary when MAZDA C lamps are used. Practically all types of fixtures of this nature on the market are sufficiently large to provide the necessary radiation. From a maintenance standpoint ventilation is undesirable, for with it a current of air passes through the fixture, and dust is naturally deposited on the glassware and lamp. With a fixture tightly closed, this action is negligible.

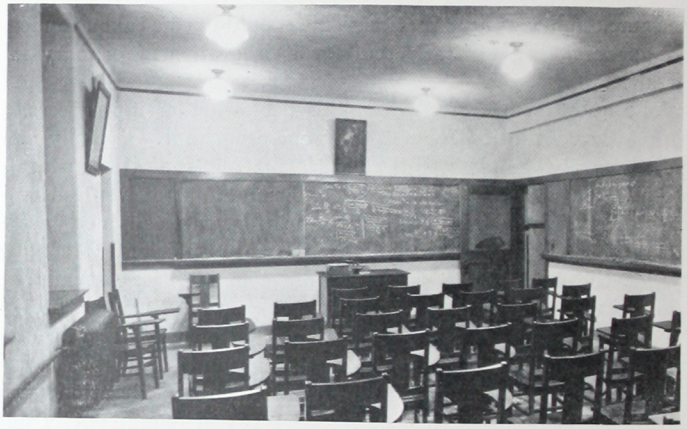
A number of factors must be taken into consideration when making a choice between commercial types of equipment of any one class. Of the equipment under consideration, *i.e.*, the enclosing diffusing unit, one important element is the intrinsic brilliancy of the glassware. This is dependent on the character of diffusion produced, the size of globe or glassware, and the wattage of the lamp used.

If the diffusion is inadequate, as, for example, that produced by a sand-blasted clear glass globe, there will be a bright spot opposite the lamp, while the rest of the globe will be considerably less brilliant. The bright spot is the determining element. Assuming, however, that the globe gives good diffusion, the brightness will then depend on the diameter of globe and the size of the lamp used. A given globe might be entirely satisfactory with a 100-watt lamp, but very unsatisfactory with a 300-watt lamp. For the position and height ordinarily encountered in classroom lighting, a maximum brightness of three candles per square inch should not be exceeded.

The following table indicates the minimum desired diameter of enclosing globes, the diameter to be measured at the maximum width:

With 100-watt MAZDA lamps	12 in.
With 150-watt MAZDA lamps	14 in.
With 200-watt MAZDA lamps	16 in.
With 300–500-watt MAZDA lamps	18 in.

Some of the forms of fixtures under consideration have a portion of the globe of clear glass, and it is well that such equipment be examined for the possibility of filament reflections or images in



An example of direct lighting with prismatic glass enclosing units, using 200-watt MAZDA lamps. An average intensity of 12 foot-candles is assurance that classroom work may be carried on efficiently without eyestrain.

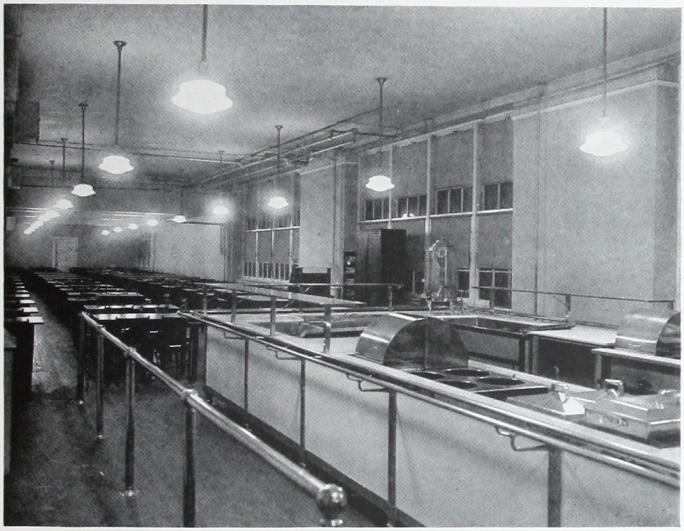
the unit itself. With the globe of uniform character, such as opal glass, these do not occur. So-called semi-enclosing units must be very carefully designed to avoid these images.

There is comparatively little choice between the various fixtures of the type under consideration as to their efficiency with light-colored surroundings. If the ceiling is dark, it is apparent that any type which emits considerable light upward will not be as efficient as the semi-enclosing units or those provided with some sort of a reflector, which has the property of directing the major portion of light into the lower hemisphere.

The shape of the uniform diffusing globe is, however, very important. The squat, or flat, type is more efficient than the spherical, or stalactite, shape in directing the light downward and emitting

less toward the upper part of the side walls, where it is of comparatively little service.

Light on the ceiling is not at all objectionable; in fact, it is desirable, as when reflected downward it reduces contrasts and softens shadows. Therefore, it is generally advisable to paint the ceiling a light tint, regardless of the type of lighting installed.



Night view of a well-lighted high school cafeteria. Enclosing glass units with 100-watt MAZDA lamps, spaced on centers 11 by 12 ft., produce adequate illumination for this class of service.

A typical specification for a school lighting unit of the diffusing enclosing type might be drawn up as follows:

The glassware should be of thin, blown, opal or cased glass, giving diffusion of the same order as that produced by (insert trade name of suitable diffusing glass, such as Genco, Radiant, or Monax).

It shall be of such a size that the brightness, with recommended size of lamp, is not over (insert the desirable candles per square inch).

The light output of a complete unit with holder shall be better than (insert per cent of clear bare lamp output desired).

It shall be of such a shape that the horizontal section is greater than the vertical section.

The supporting holder shall be sufficiently strong and of such a type as to preclude any possibility of the glassware falling.

The method of support shall be such that the globes can be readily removed for cleaning.

Similar specifications can be readily drafted for other forms of equipment.

The Lighting of Service Rooms, Corridors, etc.

Many of the schools today have cafeterias or lunch rooms, and in order to utilize less valuable space they are often located in the basement. On account of such locations, artificial illumination is frequently required, even in the daytime; consequently adequate provision for these places is essential.

Night view of a school corridor. A simple type of diffusing globe with 150-watt MAZDA lamp are used on 20 foot centers. The corridor is 15 ft. wide and the intensity on the floor is approximately 2 foot-candles.

An even illumination of from 3 to 6 foot-candles is desirable. Enclosing diffusing glass units with MAZDA C lamps are well suited for places of this sort.

The lighting of wash rooms, locker rooms, and cloak rooms is purely utilitarian. The decorative element is not especially important; desirable levels of illumination should be supplied in the most efficient manner. Direct lighting with prismatic or dense opal bowl reflectors, with outlets spaced symmetrically throughout the room, is suitable, allowing from ½ to 1 watt per sq. ft. of floor area.

While the primary function of corridor illumination is to provide light for anyone to pass along without danger of stumbling or

interfering with another person, yet the general appearance must be taken into consideration. Frequently a small, ornamental type of fixture is desirable, particularly in the lobby and main corridors.

The lighting can be accomplished with relatively low wattage lamps, on fairly wide spacings, provided diffusing glassware is employed. Uniform illumination is not necessarily essential. Smaller sizes of the same general type of equipment used in a

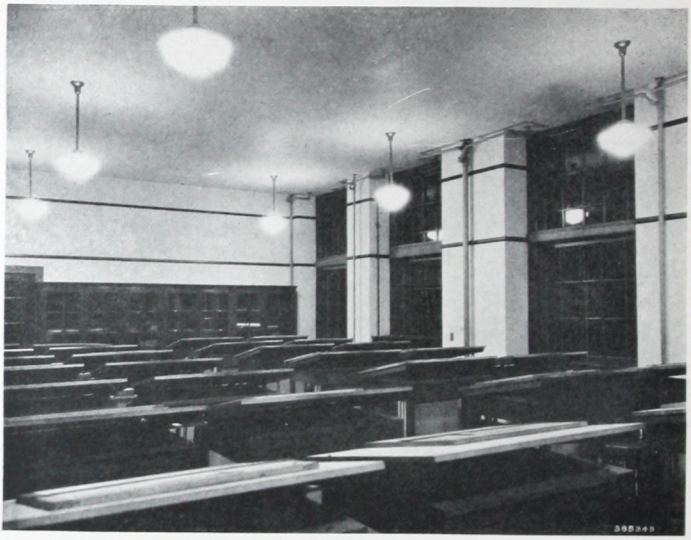
Chemistry laboratory lighted by 200-watt, MAZDA lamps in enclosing globes on 12 foot centers. A uniform illumination of 8 foot-candles is obtained on the table tops.

classroom can be utilized for the corridors. A row of outlets symmetrically spaced along the center line of the ceiling is generally to be preferred, although sometimes the structure is such as to make ceiling outlets inadvisable. In these cases, brackets or wall fixtures must be employed. In general, 100-watt MAZDA lamps on 12-foot centers are adequate. With corridors over 8 feet wide, larger lamps are necessary.

The Lighting of Shops, Laboratories, etc.

The machine and pattern shops have special demands for artificial illumination, which are quite different from those of other parts of the building. The ceilings are frequently low, necessitating

rather close spacing of outlets; overhead belting and shafting often render the use of the enclosing globe type of equipment impracticable and overhanging parts of machinery often require special location of outlets. In general, the use of RLM Standard dome reflectors, spaced on 10-foot centers, and equipped with 200-watt white bowl MAZDA lamps will produce satisfactory results. For more detailed discussion of this subject, Bulletins LD-134A, *Lighting of the Metal*



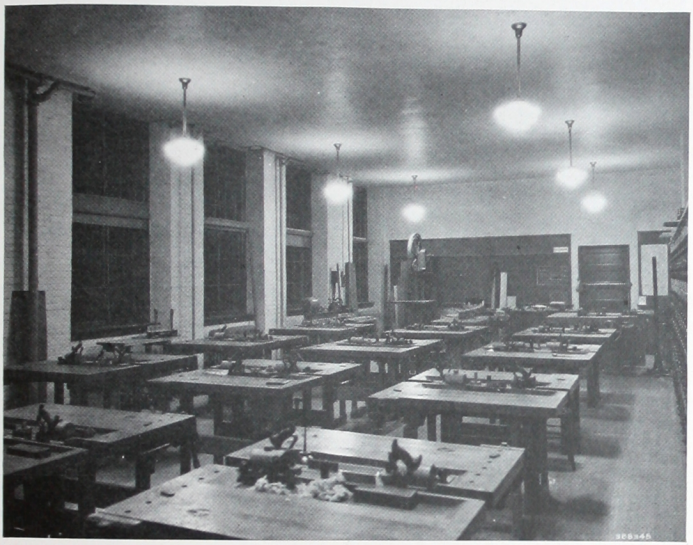
Night view of a mechanical drawing room. Opal enclosing globes on 11 foot spacings equipped with 200-watt MAZDA lamps provide an average illumination of 15 foot-candles on the table tops. The white walls and ceilings are of material aid in obtaining these results.

Working Industries, and LD-142, *The Lighting of Woodworking Plants*, which treat of machine shops and woodworking plants, should be consulted.

Laboratories require relatively high levels of illumination, in order that the progress of experiments may be carefully watched. The general layout suggested for the classroom is satisfactory for the laboratory. In chemistry laboratories, however, acid fumes may attack the metal parts of ordinary fixtures and soon make them useless. For this reason, porcelain enamel or other suitable acid resisting fixtures should be used. If equipped with these acid

resisting accessories, enclosing globes are quite suitable for use in the chemistry laboratory.

In the chemical and biological laboratories artificial daylight lamps are of considerable service in accurate determinations. A more complete discussion of their application will be found in Bulletin LD-104B, *Artificial Daylight for Merchandising and Industry.*



Night view of manual training room lighted by 200-watt MAZDA lamps in opal enclosing globes. A high grade of work will be produced and cleanliness will prevail when ample light is provided.

In the manual training room convenience outlets are advisable, with a capacity sufficient to take care of electrically heated glue pots and small motors. In the physics, chemistry, and biology laboratories, each station should have its convenience outlets to which the student can attach electric bake ovens, centrifugal machines, immersion heaters, and like appliances.

The auditorium should have a well equipped motion picture booth for exhibiting standard films. The MAZDA lamp for motion picture projection, with its economy and convenience of operation offers decided advantages to the school.

Stereopticons and motion picture machines are becoming important factors in our educational system. (See Bulletin LD-107B,

The MAZDA *Lamp in Projection Service.*) Every classroom should have an outlet to which these can be attached.

Auditorium lighting is discussed in greater detail in Bulletin LD-145A, *The Lighting of Theaters and Auditoriums*, for here the decorative element plays a most important part.

Night photograph of a gymnasium lighted by 300-watt white bowl MAZDA lamps in prismatic reflectors designed for high mounting. The spacing is 18 ft. by 18 ft. and the hanging height 22 ft. An intensity of 6 foot-candles is provided on the floor.

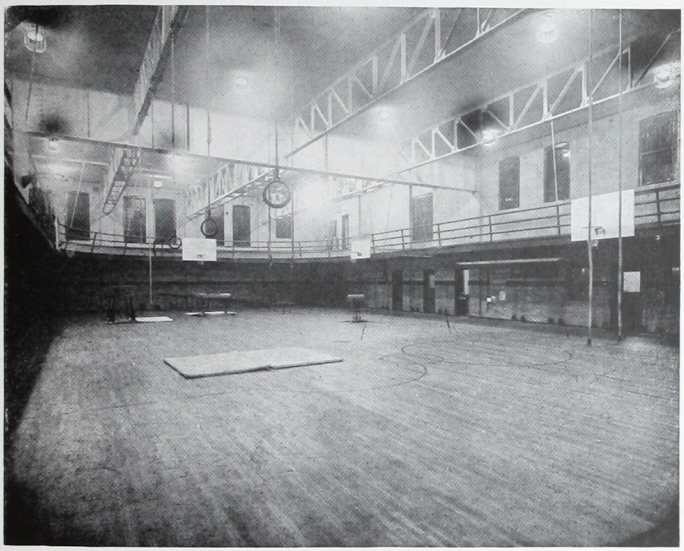
The Lighting of Gymnasiums

The gymnasium is usually rectangular in shape, with a rather high ceiling. An arrangement used frequently has a running track as a balcony 6 to 8 feet wide, around all four sides of the room. In the center of the main floor are the principal pieces of apparatus, horses, bucks, jumping standards, and parallel bars, while the flying rings and horizontal bars hang from the main ceiling. These can usually be pushed aside or drawn up out of the way for basketball, indoor baseball, and wrestling matches, or practice.

Below the balcony are found exercisers, of various types, and racks for wands, dumb bells, and Indian clubs. The illumination on the apparatus attached to the side wall below the track need not be as high as in the open space, yet in many cases it is necessary

to provide relatively small lamps, properly shaded, in order to prevent dense shadows.

The center space requires even illumination of a fairly high level, with lamps so located that the hanging apparatus will not cause objectionable shadows. Particular attention should be paid

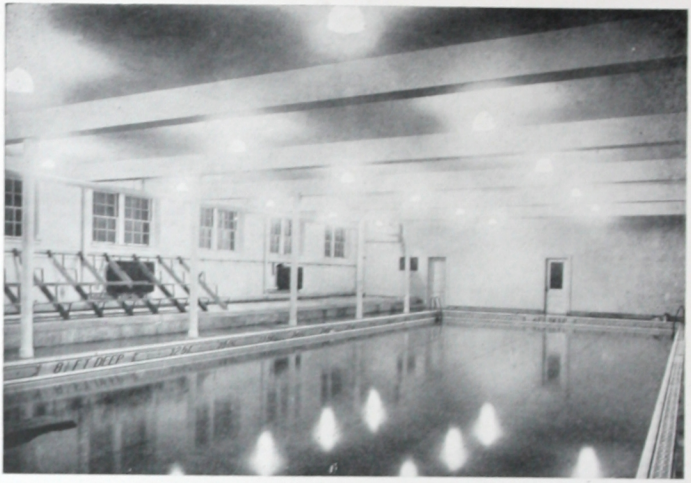


An intensity of 4 foot-candles is supplied on this gymnasium floor by means of units employing 300-watt MAZDA lamps in opalescent glass reflectors, the entire unit being protected by a wire guard.

to the shielding of the lamp filament from the eye, for one is forced to look upward a great deal when playing basketball and often faces the ceiling in ring and bar work. A blinding effect is particularly serious at these times and may cause a bad accident.

An average illumination ranging from 6 to 10 foot-candles is desirable. Different types of reflecting equipment may be employed, but practice indicates a preference for some one of the three types of direct lighting units: RLM Standard dome reflectors, deep bowl glass or enclosing globe glass. Wire guards are usually provided to protect the reflectors or lamps, or both, as the case may be. When open mouth reflectors are used, white bowl MAZDA C lamps are desirable in order to reduce the glare, except that, with mounting heights of 16 feet or over, clear lamps will be satisfactory.

In some instances, the ceiling of the building is of such a character that efficient lamps with deep bowl mirrored glass reflectors can be recessed so that the mouths of the reflectors are flush with the ceiling. This arrangement directs light strongly downward; lamps are not visible unless one looks directly upward, and there



Night photograph of a swimming pool lighted by 100-watt MAZDA lamps in bowl shaped light density opalescent glass direct lighting reflectors.

is no danger of breakage. Such an installation is shown in the upper illustration on page 4.

Sometimes, when opaque reflectors are used for direct lighting, a number of small lamps are also provided in inverted reflectors, which direct light to the ceiling and prevent it from being totally dark.

Although in most cases the running track extends about the main exercising room, and the general illumination is sufficient for the track, sometimes a long track is installed in the form of a low tunnel. For such conditions, angle type reflectors pointing in the direction the runner is proceeding avoid any likelihood of glare, and direct the light where it is required.

If the gymnasium is to be used for playing basketball, it is often advisable to provide some means of lighting the back boards to a rather high level of illumination. Enamelled steel, angle type reflectors are well suited to this purpose. They should be so located as to reduce to a minimum the possibility of their being struck by

the ball in play; suitable wire guards should be provided to protect the lamp and reflector from possible damage. Glass back boards are often a source of annoying glare unless they are completely painted over with a matt white paint.

Corridor and locker room lighted by 100-watt MAZDA lamp in opal glass direct lighting reflectors on 10 foot centers over each aisle.

The Lighting of Swimming Pools

This room, from a lighting standpoint, is practically a modified Ulbricht sphere, for the side walls and ceiling are generally of white tile. The type of reflecting device employed makes but little difference in the illumination. Care should, of course, be taken to insure satisfactory eye protection.

Under-water illumination is sometimes provided by recessing special projectors in the side walls of the swimming pool. Considered alone, such a system seems to be quite expensive, but in relation to the total cost of the pool it is a fairly small item.

The Lighting of Shower and Locker Rooms

In the shower room there is no special problem in regard to lighting, but on account of the high percentage of vapor present in the air, it is advisable that moisture-proof electric fittings be employed.

In the locker room, double rows of lockers, with aisles between, extend, in most cases, to the ceiling. The athletes dress in these aisles. Mirrors are ordinarily placed at the ends of rows on the main aisle. Inside frosted MAZDA lamps of rather low wattage, in opal glass reflectors or enclosing globes, mounted over the locker aisles, provide quite suitable illumination. Larger lamps with suitable reflectors, localized near the mirrors on the main aisle, are essential.

The Lighting of Miscellaneous Exercising Rooms

These comprise the wrestling, boxing, and fencing rooms, together with the medical director's office. Fencing requires a relatively high level of illumination, and it is probable that one room only will be provided for all these sports. In such cases, the lighting layout must be considered from the standpoint of fencing.

Since the action is rapid, it is essential that the light be well diffused and of high level, in order that all movements may be readily followed.

The finish of these rooms is usually light in color, with smooth ceilings, making indirect and semi-indirect systems of illumination quite feasible. Approximately 2 watts per square foot of floor area with MAZDA C lamps, prove satisfactory with semi-indirect lighting. As the rooms are often decorated with prizes, pennants, etc., the decorative element of the fixture is important.

In the medical director's office, the ordinary requirements for office lighting are experienced, as well as the necessity for plenty of light in all parts of the room, for physical examination. Totally indirect or dense glass, semi-indirect, units are suitable.

The Foot-candle Meter

The small portable photometer, known as the foot-candle meter, will be of practical use in any school. This instrument enables one to read at a glance the illumination on the desk, workbench, or table. It is most simple in operation and very compact. The foot-candle meter will prove very valuable to Boards of Education, architects, designing engineers, and others having charge of school and gymnasium lighting. With its aid they are enabled to check

up existing installations and to determine whether the illumination conforms to modern standards, which insure protection of the eyesight. In planning new buildings, much interesting information on both natural and artificial illumination conditions can be obtained if the device is used. No school system can afford to be without one, if those in authority are giving due consideration to the question of providing proper lighting.

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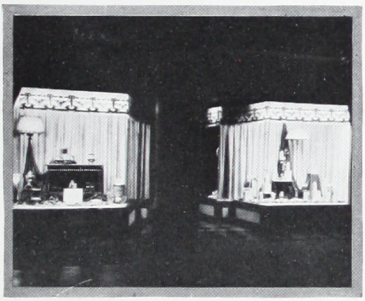
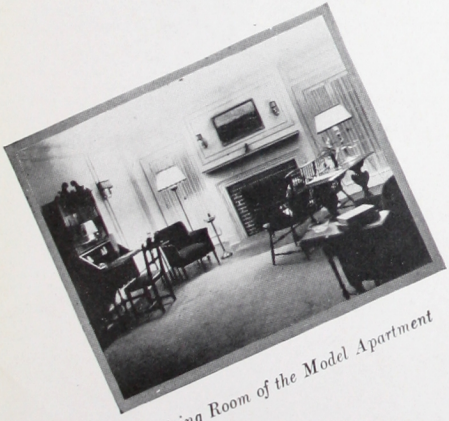
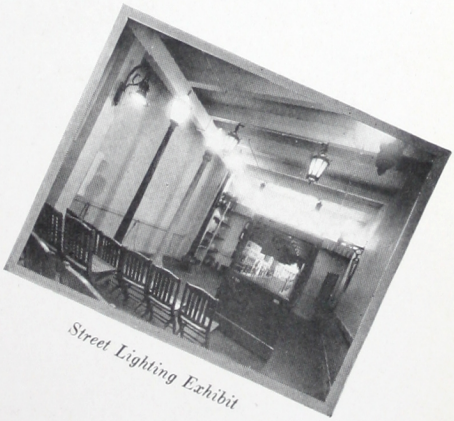


Model Show Windows



Living Room of the Model Apartment



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